# Success and Challenge With Reducing Tillage in an Organic Cropping System

**W. Curran[1], M. Barbercheck[1], M. Dempsey[1], C. Keene[1], S. Mirsky[2], M. Ryan[3], M. VanGessel[4], and J. Wallace[1]**

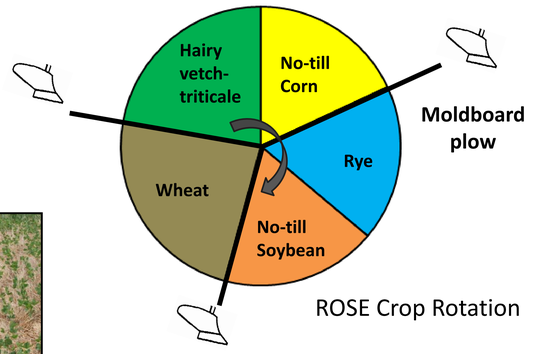
**[1]Penn State University, [2]USDA-ARS-Beltsville, [3]Cornell University, and [4]University of Delaware**

## Overview

Cover crop-based organic rotational no-till relies on cover crops for weed suppression in cash crops. A large amount of cover crop biomass is grown and terminated with a roller-crimper to form a weed-suppressive mulch. The cash crop is no-till planted into the heavy residue. This system has the potential to save organic farmers time and fuel compared to tillage-based organic grain production in which a cover crop is plowed and in-season weed control relies on soil disturbance. The Reduced-tillage Organic Systems Experiment (ROSE) was conducted from 2011-2013 at three sites in the mid-Atlantic: southern Delaware, central Maryland, and central Pennsylvania. The crop rotation was corn-soybean-wheat and it was a full entry experiment. Corn was no-tilled into hairy vetch/triticale and soybean was no-tilled into cereal rye. This was rotational no-till as all entry plots were still plowed annually (see diagram to the right).

**Objectives:** 1.) Test the feasibility of organic rotational no-till management in a systems experiment; 2.) Determine if manipulating the timing of cover crop termination/cash crop planting is a viable weed and insect pest management tool; 3.) Evaluate the suitability of ROSE rotation across the mid-Atlantic region.

**Methods:** 1.) Manure and cover crops were a primary source of nutrients. 2.) Supplemental irrigation was provided in some locations and years. 3.) Split-Split plot with four reps: Main plots A. Three termination/planting dates in corn and soybean (early, middle, late; Subplots B. Supplemental weed control with high residue cultivator vs. none; and Sub-Sub plots C. Varying variety maturity for corn (85 to 104 day) and soybean (Group 1.1 – 3.8). Measurements included cover crop biomass, weed density and biomass, cash crop population and yield, invertibrate pests and insect beneficials, and some soil quality parameters.




ROSE Crop Rotation

Rolling hairy vetch (left) and hairy vetch regrowth (right).

- We started with a single pass with the roller-crimper. This was inconsistent (see image, left).
- In years 2 and 3, two passes improved control.
- We discovered we had a narrow window to control covers with the roller-crimper without allowing seed production and the potential for volunteers (Fig. 1).
- You have to tolerate a few volunteer cover crops in this system.

- Typical no-till equipment may not handle this much residue (see image).
- Difficult to slice through the heavy residue and seed placement and lack of seed furrow closure can be problematic.
- Poor seed to soil contact reduced corn and soybean populations in some locations and years (Fig. 2).
- We have continued to tweak our planting equipment every season.

Reduced crop stand with high cover crop residue.

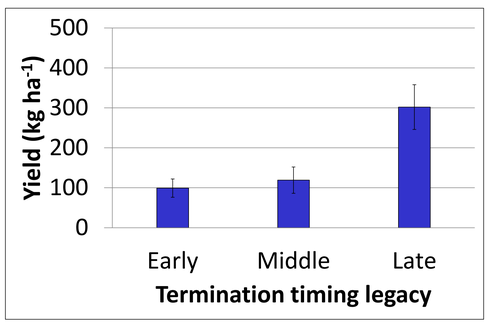



Figure 1. Cereal rye contamination in winter wheat in PA in 2012. Late rolled cereal rye allowed seed set more than earlier rolled rye.

Expectation 1 – cover crops can be controlled with the roller crimper

Expectation 2 – we can successfully no-till into heavy cover crop residue

Expectation 4 – Rolled cover crops will need help in supplying adequate weed control

Expectation 3 – Early-season insect pests will be a problem in this reduced-till high residue system

Biomass production at each site

Cereal rye
- DE: 6,700-10,800 kg ha$^{-1}$
- MD: 5,000-11,200 kg ha$^{-1}$
- PA: 4,500-8,600 kg ha$^{-1}$

Hairy vetch/triticale
- DE: 4,000-7,000 kg ha$^{-1}$
- MD: 4,500-6,000 kg ha$^{-1}$
- PA: 5,500-6,500 kg ha$^{-1}$

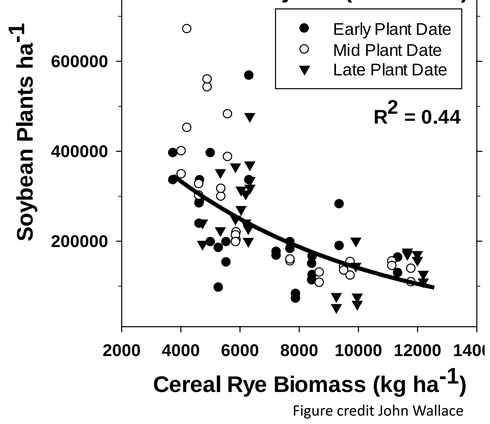



Figure credit John Wallace

Figure 2. Soybean population vs rye biomass at Maryland.

High residue cultivator

Delaware 2012
Middle cultivated soybean

Delaware 2012
Late not cultivated soybean

*nysipm.cornell.edu*

True Armyworm

Variegated Cutworm


Damaged corn seed

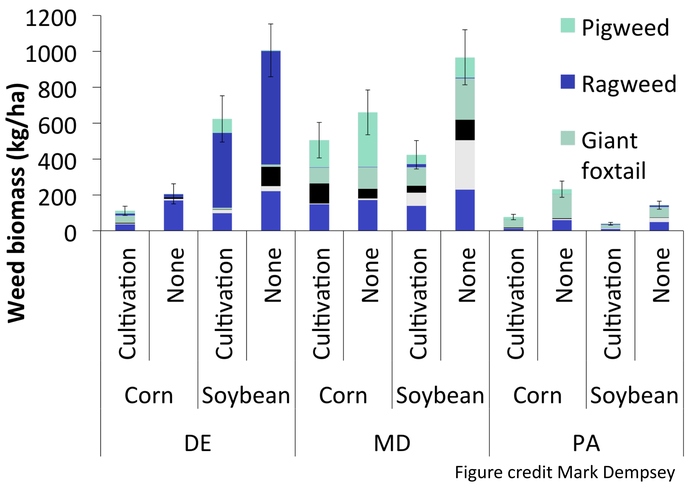



Figure credit Mark Dempsey

Figure 4. Effect of high-residue cultivation on weed biomass.

- Cover crops produced 4,500-11,200 kg ha$^{-1}$ cereal rye and 4000-6500 kg ha$^{-1}$ hairy vetch/triticale (see text above right).
- Shallow high-residue cultivator was effective at reducing weed biomass (Fig. 4).
- Cultivation improved yields where weed competition was high (Delaware).
- Cultivation was not necessary where weed competition low (Pennsylvania) and actually hurt soybean yield.

- We hypothesized that early-season insect pests could be avoided by delayed planting.
- Observed that bio-control services increased as planting was delayed.
- Invertebrate pests never reached damaging levels in PA.
- Predation increased each year of organic management (fig. 3).

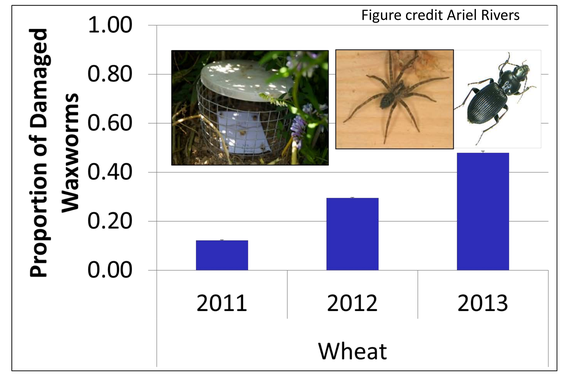



Figure 3. Increase in predation over 3 years in Pennsylvania.

**Key findings:**

- Cash crop yields were competitive and highest when cover crops were controlled and lowest when residue impacted crop stand and when cover crop regrowth occurred. We conclude that multiple passes with the roller-crimper may be necessary for control depending on growth stage; and cash crop planting equipment modifications are needed when dealing with heavy cover crop residue.
- Insects: beneficial insects responded positively to organic management with increased pest-suppression services.
- Weeds: Supplemental weed control was necessary where annual weed density was high and vice versa. Starting with a low weed seed bank will maximize the probability of being able to maintain good annual weed control in this system.
- Pieces of our rotation/ management ready for innovative farmers, but the overall cropping system has serious challenges and is not ready for primetime.

Research funding provided by USDA OREI Award No. 2009-51300-05656, USDA-NIFA-ICGP-002796.